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THESIS

**TRAINING EFFECTIVENESS STUDY OF SIMULATOR
USAGE AND ITS IMPACT ON LIVE FIRE ARMOR
GUNNERY**

by

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June 2014

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IMPACT ON LIVE FIRE ARMOR GUNNERY**

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ABSTRACT

It is mandatory for tank commanders and gunners to train in the Advanced Gunnery Training System (AGTS), but the effectiveness of conducting this training is unclear. Although anecdotal evidence suggests that training transfer may be occurring, previous research could not definitively prove that training transfer is occurring between the simulator and the performance during live fire gunnery qualification. The purpose of this study was to assess whether there was a correlation between performance in the AGTS and modified live fire gunnery. Sixty-five participants from the Army Armor School volunteered for this study. Data was collected on their AGTS and live fire performance. Results indicated there was no significant correlation between performance in the AGTS and on the modified live fire gunnery. Exploratory analyses showed those who had completed the AGTS Gate to Live Fire performed better on the modified live fire gunnery than those who had not completed the AGTS training. This result suggests that training transfer may be occurring. Given that specific metrics are identified and incorporated into the AGTS, there is strong potential for simulation training to allow individuals to attain a higher level of proficiency than would be attained by just live training.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAR	After Action Review
AGTS	Advanced Gunnery Training System
AIM	Abrams Integrated Management
CALFEX	Combined Arms Live-Fire Exercise
CITV	Commander's Independent Thermal Viewer
COAX	Coaxial Machinegun
CPC	Crew Practice Course
FBCB2	Force XXI Battle Command Brigade and Below
FLIR	Forward Looking Infrared
GST	Gunnery Skills Test
GTLF	Gate to Live-Fire
HBCT	Heavy Brigade Combat Team
I/O	Instructor/Operator
IRB	Institutional Review Board
MPL	Minimum Proficiency Level
NBC	Nuclear, Biological, Chemical
PC	Personnel Carrier
SEP	System Enhancement Program
TC	Tank Commander
TIS	Thermal Imaging Sensor
UCOFT	Unit Conduct of Fire Trainer
VC	Vehicle Commander
VCE	Vehicle Crew Evaluator

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I. INTRODUCTION AND BACKGROUND

This thesis explores the performance of an individual in a tank simulator and their subsequent performance conducting similar engagements during modified live-fire gunnery. Past studies have shown there was no correlation between the performance in the simulator and the performance during live-fire gunnery. Past studies have provided anecdotal evidence though that simulators do provide training value.

A. MOTIVATION AND PROBLEM STATEMENT

In 2003, I attended the Armor Officer Basic Course where I went through training on the M1A1 Abrams Integrated Management (AIM) tank. This is a predecessor to the current variant, the M1A2 System Enhancement Program (SEP) Version 2 tank. I was trained in a simulator, the Unit Conduct of Fire Trainer (UCOFT), and when complete executed a live-fire familiarization on the actual tank. This consisted of a series of engagements, both day and night that demonstrated to the student the capabilities of the tank. I fired the tank in the gunner and tank commander's positions. I conducted training in the course that taught me how to maneuver, conduct maintenance, and other courses that an armor officer needs, but this was the only training I was to receive on actually firing the tank before being assigned as a platoon leader of a tank platoon that was already deployed in support of Operation Iraqi Freedom. If it was not for the training I received in the basic course, I would have had no experience on the tank, as I tried to lead my platoon in combat operations. I credit my platoon sergeant, a gifted tanker and good friend, and the rest of my platoon with the success we had in Iraq, but the training I received helped ensure I was prepared to execute my job as a platoon leader. This experience has motivated me to investigate training methodologies and systems and how those are used to train Soldiers to execute their real-world missions. The research conducted investigated whether there is a correlation between the results captured in

simulator usage and the results of those same individuals as they execute the same tasks in a live-fire event.

Prior to executing the live-fire qualification, the armor community currently requires all tank crews to use a simulator, Advanced Gunnery Training System (AGTS), which is similar to the UCOFT. This simulator allows the tank commander and gunner to practice in a highly accurate replica of the actual tank commander and gunner stations inside the tank turret. Although simulator usage is required, the United States Army's doctrinal purpose for executing the simulator training is "to ensure the crew possesses the skills and experience necessary to safely execute live-fire gunnery" ("Heavy Brigade Combat Team [HBCT] Gunnery," 2009, p.12-6).

Safe operation of the tank is more than just the tank commander and gunner being able to coordinate fire commands inside the turret during an engagement. The safe operation involves all of the crew members of the vehicle executing their individual tasks to a high level of proficiency. These tasks can range from normal operational level maintenance to the ballet of live-fire. Every crew member has a set of important tasks they must accomplish before the gunner can even pull the triggers and send a round towards a target. The identification of all of these tasks is critical to ensure the United States Army maintains highly trained and proficient tank crews, especially with the increasing impact felt by declining budgets.

Safety is imperative in operating an armor vehicle; however, the simulator can provide more than just those skills required for safe operation. Due to the cost in conducting live-fire and today's fiscally austere environment, it is imperative to exploit all of AGTS capabilities to more provide more effective training. A tank is an expensive system to maintain and operate. Between the cost of maintenance, fuel, and ammunition, it becomes quickly apparent that tank units must determine what tasks can only be trained and certified during live training and what training can be taught using other less costly methods, including virtual, gaming, and potentially constructive approaches.

The AGTS simulator has the capability to train specific individual and collective tasks that transfer to live execution of those same tasks. We must identify which tasks when successfully completed in an AGTS; indicate a level of proficiency that will transfer to success on the battlefield and those tasks which are required to be completed in a live tank on a training range to produce success in war. For example, the command could focus live training on more difficult individual, crew, and collective tasks if the crews have met an identified level of proficiency on more basic tasks through other means, such as simulation. Doing so would reduce the time spent in live training, which results in resource savings, or allow the live training to focus on tasks which can only be trained live, resulting in a better trained force at the same cost.

Once these tasks are identified and metrics developed to place a value on the level of training accomplished, commanders can then ensure crews receive training based upon the crews' needs, and not the end criteria of simply completing a certain exercise in the simulator. The purpose of this thesis was to address the gap in knowledge regarding which tasks and metrics in the AGTS best transfer to live-fire.

B. RESEARCH QUESTIONS AND CORRESPONDING HYPOTHESIS

Is there a correlation between the crew score during the Gate to Live-fire (GTLF) exercise utilizing the Advanced Gunnery Training System and Table 6 modified live-fire gunnery qualification?

H_0 (Null hypothesis): There is no correlation between the tank commander and gunner score from the GTLF utilizing the AGTS and the score of the Table 6 modified live-fire gunnery.

H_A (Alternative hypothesis): There is a correlation between the tank commander and gunner score from the GTLF utilizing the AGTS and the score of the Table 6 modified live-fire gunnery.

Exploratory: Is there a significant statistical difference between those who completed all of their AGTS level exercises and those that did not on the Table 6 modified live-fire gunnery?

C. SCOPE AND OVERVIEW

This thesis limited the tasks investigated to those captured by both the AGTS and during the live-fire on the crew score sheet. These tasks are fire commands, crew engagement times, hit or miss, and overall score for an engagement. By limiting the results of the identified tasks, an observational study was conducted that evaluated current practices in the armor community without introducing new metrics. The study also contained a survey to understand the demographics of the participants along with their perceptions on the training effectiveness of the AGTS in relationship to the live-fire gunnery.

D. LITERATURE REVIEW OF RELEVANT STUDIES

The studies referenced in this literature review were conducted by the U.S. Army Research Institute for Behavioral and Social Sciences between the years of 1987 and 1994 (Black & Graham, 1987; Campshure & Drucker, 1990; Hagman, 1994; Hughes, Butler, Sterling, & Berglund, 1987; Kraemer & Rowatt, 1993; Smith & Hagman, 1992; Smith & Hagman, 1994). Notably, no studies since 1994 have addressed the question as to whether simulation training is correlated with live-fire performance. Thus, no studies have been conducted on the current simulation system, AGTS, an important omission as the AGTS is a more sophisticated and realistic simulator than was used in the 1980s and 90s.

These studies were of two types, those that quantitatively assessed training transfer from simulator to live-fire, and those that focused on the culture of using simulation training.

1. Studies that Assessed Training Transfer

Of most relevance to the current study, three studies did examine training transfer of individual tasks from simulator training to live-fire, in particular, reticle

aim and time for first round on target (Hughes et al., 1987; Campshure & Drucker, 1990; Smith & Hagman, 1994). Reticle aim was used by the UCFT's computer as a metric to determine how fast the crew could progress through the training matrices. In both the Hughes et al. (1987) and Campshure & Drucker (1990) studies, it was interesting to discover that the majority of tank crews (tank commander and gunner) had not completed all of the exercises that were described as necessary prior to conducting their live-fire gunnery tables. This was due to insufficient time allocated prior to the live-fire gunnery and demonstrates that each crew is different in how fast or slow they can progress in the training.

Results across these studies consistently showed that crews that had conducted simulator training were actually able to detect the target and engage it quicker than those that had less or no simulator training. This time difference was noticed during the initial live-fire tables, but the difference became less significant as the crews progressed through the live-fire tables to the point that when the crews shot their final qualification table, there was no appreciable difference between crews. Of interest is the idea that if training in the simulator actually benefited crews in acquiring targets and engaging them quicker, it is possible that the tables could be revised to start crews at higher levels of engagements. This idea requires there be some metric that captures a crew's proficiency to ensure in fact that crews could start at a higher degree of difficulty.

2. Studies Examining the Culture of Using Simulation

The overall take away from the literature reviewed was that the simulator was providing valuable training. Seven studies reviewed conducted quantitative measures on crew performance, although only the three previously mentioned studies looked at training transfer between simulator and live-fire. Hughes et al. (1987) and Smith & Hagman (1992) went one step further and used qualitative measures in the form of surveys given to the crews to gain additional insight into simulator usage. These surveys asked the individuals what they perceived as the

benefits and drawbacks of the simulator and its use in preparing for live-fire gunnery. It is important to note that while the surveys are the Soldiers' opinions, it is the "buy-in" that an individual has that the system is working that gives the system its value. Command and crews generally felt that the simulator contributed to their training, but many stated it should not be considered a replacement to live-fire gunnery. Complaints ranged from not realistic enough to that "gut feeling" that simulations cannot replace the real thing. The largest positive comment was the feeling that the simulator would be a good tool for crew to maintain proficiency once they had qualified during live-fire gunnery. This acceptance that a simulator can provide the valuable training necessary to prepare crews ultimately ensures commanders integrate that system into their training plans.

The article by Blackwell and Brown (1994) discussed that certification in the UCOFT is necessary; however, it failed to identify from the command perspective exactly what the UCOFT was accomplishing in quantifiable terms. The general consensus seemed to be, "We know it is making our crews better, we just can't prove it to you."

Crew experience was another theme discussed throughout all of the studies. Although it is important to know who the participants of the study are, crew status seems to be a more important variable than the experience level of the individual tank crew members. The Army realizes that crews will have turbulence due to the Army's individual Soldier assignment system that keeps Soldiers moving every three to four years between duty stations. The armor and cavalry community also understands this turbulence with the designation of crews being considered in either a new, turbulent, or sustainment status. Although crews were identified by the chain of command during the gunnery process, it was noted that the new or turbulent crews generally did not have enough time to accomplish all of the simulator training required (Hughes et al., 1987). Many of these crews completed the minimum that allowed them to conduct the live-fire gunnery (Hughes et al., 1987). This lack of emphasis on

simulator training demonstrates that while individuals generally “felt” the simulator was doing something, live training trumped all else in the final determination. It would be interesting to see if the culture of using simulation has changed since these studies were conducted. In summary, few studies have examined training transfer from simulator to live-fire in tank crews. The attempt by these studies to address the training transfer of tasks from the UCOFT to live-fire were adequate for the first fielding of the Abrams tank and the simulator to support the training of the tank commander and gunner. The Abrams tank and the simulator have gone through upgrades as new technology has been developed and then integrated into the platforms. The Army’s training strategy for tank crews has also changed with lessons learned from being at war for ten years. It is currently unclear due to the 20 years’ worth of changes, the increasing acceptance of simulation usage as evidenced in the Army gunnery training program and the improvements to the AGTS, what the level of training transfer is from the AGTS simulator to live-fire.

E. ARMY GUNNERY TRAINING PROGRAM

The Army has developed a training program that provides commanders and their trainers a framework from which to build their training program. This framework ensures commanders and trainers throughout the Army are conducting training to a base standard. Having this base standard also allows provides commanders and trainers with the flexibility to adapt their training programs based upon their current location and mission requirements.

1. Training Methodology

The United States Army gunnery training program consists of three different phases, individual, crew, and collective training. The Army defines these phases as:

a. Individual

The individual gunnery phase trains individual crewman on crew level skills, using classroom and home-station training in conjunction with the Gunnery Skills Test (GST).

b. Crew

The crew gunnery phase develops crew skills on Tables 1, 2, 3, 4, and 5 and culminates in crew qualification on Table 6.

c. Collective

The collective gunnery phase develops section and platoon coordination and fire control and distribution on Tables 7, 8, 10 and 11, culminating in section and platoon qualifications on Tables 9 and 12. There are also guidelines for executing a company-level combined arms live-fire exercise (CALFEX) with organic indirect fire and sustainment unit support. ("Heavy Brigade Combat Team [HBCT] Gunnery," 2009)

This delineation into three phases allows for tasks trained in an earlier phase to be integrated into the next phase. An example of this integration is fire commands. Each individual in the crew is responsible for specific fire commands based upon the type of target the crew is going to engage. Along with the fire command is a series of specific tasks and actions that the crew member accomplishes. Each crew member has their own specific responsibilities that must be executed simultaneously for the crew to successfully engage a target. Thus, the successful engagement of the target requires individual crew members to be proficient in their individual tasks, the crew to incorporate those individual tasks into crew tasks and execute those crew tasks, and finally to execute the collective section and platoon tasks with multiple tanks.

During individual training, there are multiple techniques of training each crew member. Loaders do not have a simulator, but are normally trained by the gunner in the actual tank using dummy rounds that are the same dimensions and

weight of the live round. Drivers do not have a specific simulator that they train in for gunnery, but do execute training events to improve their driving abilities throughout the training cycle. It is the tank commander and gunner on whom virtual training is focused.

Virtual training is conducted for the tank commander and gunner to develop the skills necessary to engage targets, not just for the live-fire qualification, but for combat operations also. Simulators are used to allow the tank commander and gunner to engage targets multiple times without incurring the cost that comes with firing live ammunition. The Army recognizes that tank crews will be at different levels of proficiency, and has three broad categories for tank crews. The virtual training that is conducted for the tank commander and gunner is based upon which of three categories the crew is placed.

a. *New*

“Either the VC, gunner, or both are new to their position.” (“Heavy Brigade Combat Team [HBCT] Gunnery,” 2009, p. 12-5).

b. *Turbulent*

“Both the VC and gunner have previously held the position they are in, but have not worked together as a crew.” (“Heavy Brigade Combat Team [HBCT] Gunnery,” 2009, p. 12-5).

c. *Sustainment*

“The VC and gunner have previously qualified together as a crew.” (“Heavy Brigade Combat Team [HBCT] Gunnery,” 2009, p. 12-5).

Once the proficiency of the crew is determined, a training program can be developed for that tank commander and gunner to prepare them for the live-fire gunnery qualification.

2. Army Armor Gunnery Tables

The Army conducts a series of live-fire tables in which the main goal is to ensure a crew is proficient on the tank. The culminating table for an individual crew is the Table 6, Crew Qualification. Commanders, with the master gunners and staff, have latitude in exactly what engagements his crews will execute. The primary requirement is that the commander must develop his tables to meet the Minimum Proficiency Levels (MPLs) as outlined in the Heavy Brigade Combat Team [HBCT] Gunnery manual. The MPLs for each table are outlined in Figure 1.

Minimum Proficiency Levels (MPLs)	Gunnery Table				
	II	III	IV	V	VI
One Defensive Engagement: Day and Night	Y	Y	Y	Y	Y
One Offensive Engagement: Day and Night	Y	Y	Y	Y	Y
One Short Halt or Traffic Control Point: Day OR Night	Y	Y	Y	Y	Y
One Short Range Machine Gun Engagement: Day OR Night	Y	Y	Y	Y	Y
One CBRN Engagement: Day and Night	Y	Y	Y	Y	Y
One Short-Range Engagement: Day OR Night	Y		Y	Y	Y
One Long Range Engagement: Day OR Night	Y		Y	Y	Y
GT III is Basic Machine Gun and does not have any Main Gun requirements. If GT III and IV are fired together, then the MPLs for GT IV apply. The Term "Main Gun" refers to the 25mm and the 120mm systems. The Term "Machine Gun" refers to the coaxially mounted and Caliber .50 systems.					
Weapon	Short Range Engagement		Long Range Engagement		
Machine Gun	<300m		N/A		
25mm	<800m		>1400M		
120mm	<800m		>2000m		

Figure 1. Minimum Proficiency Levels for Stabilized Platforms (from Heavy Brigade Combat Team [HBCT] Gunnery," 2009, p. 16-7)

The gunnery tables the command develops will build upon each other, ensuring the crew is proficient on their actual tank with the weapon systems prior

to executing the crew qualification. A description of the tables as outlined in the HBCT gunnery manual is:

a. *Gunnery Table 1*

“Crew Critical Skills consist of those skills that are critical to the safety of the crew and essential to the operation of the combat platform assigned. Gunnery Table I should be conducted in garrison, prior to the gunnery density” (“Heavy Brigade Combat Team [HBCT] Gunnery,” 2009, p. 16-12).

b. *Gunnery Table 2*

“Crew Practice Course (CPC) is a single vehicle CPC. CPC is designed to evaluate the crew’s ability to engage stationary and moving targets placed in a tactical array from a stationary and moving vehicle. CPC tasks are to be conducted either dry or device based prior to using the .50 cal inbore device (Abrams) or full caliber ammunition” (“Heavy Brigade Combat Team [HBCT] Gunnery,” 2009, p. 16-13).

c. *Gunnery Table 3*

“Basic Machine Gun is a single-vehicle machine gun pure table. Gunnery Table III is designed to evaluate the crew’s ability to engage stationary and moving targets placed in a tactical array from a stationary and moving vehicle using the vehicle mounted machine guns” (“Heavy Brigade Combat Team [HBCT] Gunnery,” 2009, p. 16-15).

d. *Gunnery Table 4*

“Table IV is a single-vehicle main gun pure qualification table. Gunnery Table IV is designed to evaluate the crew’s ability to engage stationary and moving targets placed in a tactical array

from a stationary and moving vehicle using the main gun” (“Heavy Brigade Combat Team [HBCT] Gunnery,” 2009, p. 16-17).

e. *Gunnery Table 5*

“Crew Practice is a single vehicle practice table. Gunnery Table V is designed to train the crew to engage moving and stationary targets using all vehicle weapon systems. It requires the crew to call on the knowledge gained throughout all previous tables. Gunnery Table V will prepare the crew for Gunnery Table VI, Crew Qualification by presenting them with tasks that require the crew to use all the aspects of their fire control system against a variety of target arrays” (“Heavy Brigade Combat Team [HBCT] Gunnery,” 2009, p. 16-21).

f. *Gunnery Table 6*

“Gunnery Crew Qualification is a single vehicle qualification table. Gunnery Table VI is designed to evaluate the crew on engaging moving and stationary targets using all vehicle weapon systems while in the offensive or defensive postures. Gunnery Table VI must be fired using full caliber ammunition” (“Heavy Brigade Combat Team [HBCT] Gunnery,” 2009, p. 16-23).

Each of these gunnery tables, except for gunnery Table 1, use the Department of Army form 7657-R, dated September 2009 (see Figure 2) to record the crew’s results. The result of each of the tables is briefed to the crew by a crew evaluator upon completion of the table. The crew evaluator has the capability to listen to the crew as they conduct the tables, and based upon the range, will have visual footage of the tank and the targets that were engaged and potentially video footage from inside the tank. This allows the crew evaluator to conduct a thorough after action review. It also allows the crew to identify issues and conduct additional training to resolve those training deficiencies.

CREW GUNNERY SCORESHEET											
For use of this form, see FM 3-20.21; the proponent agency is TRADOC.											
1. ENGAGEMENT		2. CREW		3. UNIT		4. DATE (YYYYMMDD)		5. OV POSTURE			
6. TARGET 1			7. TARGET 2			8. TARGET 3					
a. TYPE	b. RANGE	c. POSTURE	a. TYPE	b. RANGE	c. POSTURE	a. TYPE	b. RANGE	c. POSTURE	d. DELAY		
FIRING SET		DRIVER ACTION		FIRING DATA		AUTHORIZED BREAK TIMES		FIRING SET		15. CREW CONDUCT, DUTIES, AND RESPONSES/ PENALTIES AND AAR DISCUSSION POINTS	
9. A		a. Move Up b. Close		1. Open 2. Close		a. Break Start b. Break Stop		A		a. Incorrect Conduct of Fire	
10. B		1. Break Up 2. Move Up 3. Close		1. Open 2. Close		a. Break Start b. Break Stop		B		b. Improper Ammo or Wpn	
11. C		1. Break Up 2. Move Up 3. Close		1. Open 2. Close		a. Break Start b. Break Stop		C		c. Failure to ID Friendly or Non-Combatants	
12. D		1. Break Up 2. Move Up 3. Close		1. Open 2. Close		a. Break Start b. Break Stop		D		d. No Digital Battle Damage Assessment (BDA)	
13. E		1. Break Up 2. Move Up 3. Close		1. Open 2. Close		a. Break Start b. Break Stop		E		e. Incorrect Response Terms	
										f. Incorrect Engagement Techniques	
										A - Alert AW - Ammo/ Weapon TD - Target Description AZ - Direction R/E Range/ Elevation E - Execution X - Termination ST - Stoppage M - Malfunction OB - Obscuration FID - Friendly ID MF - Misfire AC - Air Cap BU - Breach Up D - Doubtful L - Lost O - Over S - Short T - Target	
14. SCORE		a. Target Type		b. Range		c. Close Time		d. Delay Time		e. Total Defects	
KILL 1								(-)		(-)	
KILL 2								(-)		(-)	
DELAY TGT								(-)		(-)	
REMARKS:										TOTAL SCORES	
										16. [Target 1] + [Target 2] + [Target 3]	
										17. Number of Total Targets Presented	
										18. Engagement Score	
										19. DQ - Disqualified	
										20. Auto Zero	
										21. 30 - Safety (30 Points)	
										22. Safety Violations	
										23. Points	
										a. <input type="checkbox"/> YES <input type="checkbox"/> NO	

DA FORM 7657-R, SEP 2009

APD PE V1.00

Figure 2. Crew Score Sheet (from “Heavy Brigade Combat Team [HBCT] Gunnery,” 2009)

F. ADVANCED GUNNERY TRAINING SYSTEM

The Advanced Gunnery Training System (AGTS) is the Army’s simulator system to train tank commanders and gunners on proper engagement techniques and procedures prior to allowing them to fire live on the real tank.

1. Capabilities

AGTS as a simulator is designed to replicate the current main battle tank of the United States Army, the M1A2. The AGTS “utilizes computer-generated

visual scenes, targetry, and special effects to simulate the engagement of targets. The majority of the fire control system is replicated in both physical and functional aspects. The system trains both fully operational and degraded-mode gunnery techniques under a wide variety of conditions" ("Tank Gunnery Training Devices and Usage Strategies,"2000, p. 5-5). The individual capabilities and limitations of the AGTS are detailed below as described in the Tank Gunnery Training Devices and Usage Strategies published in May of 2000.

a. *The System Simulates the Following Visual Effects*

- Multiple, single, and delayed targets (M1A1, M1A2, T-80, truck with snapper ATGM, T-72, BMP, BMP2, BTR, BRDM, ZSU-23-4, HIND-D, MI-8C, truck GAZ-69, rocket-propelled grenade [RPG] team, troops, M1, M2/M3, M60A3, AH-64, Leopard 1 and 2, Marder, AMX-10, AMX-30, Chieftain, Challenger, M-113, and Merkava)
- Varied ranges, speeds, exposure times, and reactive targets
- Own vehicle, moving and stationary
- Primary, alternate, and subsequent defensive firing positions
- Round tracer
- Scene obscuration
- Round impact and effect on target
- Round impact on terrain
- Catastrophic kill
- Mobility kill
- Burning wreck models
- Smoke from grenade launchers
- Enemy direct and indirect fire
- Near miss on own vehicle
- Own vehicle hit and kill.

b. *The System Provides the Following Visibility Conditions*

- Day unlimited
- Day with haze (European data base)
- Day with dust (desert data base)

- Day with fog
- Dawn and dusk
- Night unlimited (thermal)
- Night with thermal clutter
- Mortar illumination

c. *The System Provides the Following Aural Cues to the Crew*

- Enemy fire, including artillery
- Round loading and reloading sounds
- Loader's "UP"
- Main gun, M240, and M2 machine gun firing
- Track clatter
- Engine and transmission sounds
- Gun jump
- TIS cooling fan
- NBC system
- CITV fan and shutter
- Own vehicle hit and kill
- Friendly fire

2. Training and Usage Strategy

The HBCT Gunnery manual describes the AGTS as "a family of tank gunnery training simulators for VC/gunner teams. Its primary purpose is to train/sustain basic gunnery skills and increase combat gunnery skills. The AGTS places the VC and gunner in a realistically simulated crew station and presents them with a full range of computer-controlled engagement situations. The AGTS produces full-color, computer-generated action scenes in which crew members interact with various target situations. Programmed exercises vary in target type and number, range, vehicle and target motion, visibility, and other complex conditions" ("Heavy Brigade Combat Team [HBCT] Gunnery," 2009, p. 11-20). The United States Army mandates the use of the AGTS to train the tank commander and gunner.

The HBCT Gunnery Manual recommends a minimum of four hours of training in the AGTS for each crew per month to ensure the crew is able to execute all of the exercises and be ready to move onto the live gunnery tables. This recommendation of four hours, while sounding rather easy to achieve, is actually difficult when commanders must balance other missions and training requirements. If a tank company, comprised of 14 tanks, executes the four hours of training per month, it totals to 56 hours of actual training. Generally a brigade conducts gunnery train-up at any given time. This would equate under the current two maneuver battalion construct of four tank companies, or 56 tank crews needing to train. These calculations equate to 224 hours a month the brigade needs to be training these crews to meet the guidelines set forth by the HBCT Gunnery Manual. This time does not include setup time, time for after action review, or the availability of the system on which to conduct training. The major constraint most units face is the availability of the system. While theoretically Soldiers are on duty 24 hours a day, seven days a week, it is not a realistic expectation to expect the training to occur around the clock. Contractors primarily maintain and operate the simulators; therefore, commanders must take into account the budgetary aspects of conducting simulator training. Units will schedule the use of the AGTS, and depending on where they are in the gunnery training program, some units may have priority over others on usage of the system.

Commanders, as they determine the proficiency of their crews, must determine at what level of exercises the crew will start training in the AGTS. These varying requirements for crews based upon experience level do not fit well with the four hour recommended time stated in the manual. As commanders assess their crews' level of proficiency, they will make the decision on how much time crews will receive in the simulator. The main priority for commanders is to ensure all crews pass the GTLF exercises, since a crew cannot conduct live-fire until this requirement is met. With the priority being GTLF, a crew that successfully passes it exercises quickly, no matter what their experience level

will generally lose any more simulator time to allow crews with less success the opportunity to fulfill the necessary requirements. This focus on the end state of passing GTLF precludes the additional training the AGTS can provide a crew. The process ultimately becomes a “check the box” in the process to fire live instead of being used as a training tool as it was designed.

3. Gate to Live Fire

The commander must ensure that each tank commander and gunner combination satisfactorily completes the Gate to Live Fire (GTLF) exercises. The requirement is for the tank commander and gunner to score at least 700 out of a possible 1000 points over the course of ten engagements. Each engagement must also be passed with a minimum of 70 points. Any major safety or crew violations throughout the GTLF result in the crew failing the GTLF. While the GTLF is the culminating simulation event for the tank commander and gunner, the commander dictates the amount of exercises they conduct prior to it and determines whether the crew successfully progresses through the dictated exercises. The commander may establish the baseline exercises a crew must conduct, but the computer system that has the AGTS exercises also compares the crew's performance and determines what exercises they must accomplish to be ready to execute the GTLF. The computer will not allow a crew to execute the final GTLF unless it satisfactorily completes the previous exercises.

4. Limitations

The following list of items are not functionally simulated or represented on the AGTS:

- TC's periscopes. The three forward unity periscopes are operational; the other periscopes around the TC's hatch are not functional
- TC's hatch will not open
- M2 machine gun is not replicated on the AGTS
- Not all circuit breakers are supported from the display panels

- Hydraulic pressure gauge
- Gunner's unity periscope
- Ammunition temperature gauge
- Gunner's TIS focus knob
- M240 machine gun. The M240 machine gun is partially simulated. Manual fire cannot be accomplished. The charging handle can be used to apply immediate action for simulated stoppages.
- Driver's and loader's stations are not simulated

Of the limitations listed above, three are of most concern: the lack of M2 machine gun replication, the driver and loader's stations only being simulated in a very basic way, and the lack of hydraulic system simulation. Although the capabilities of the AGTS are numerous, the inability of the tank commander to practice engagements with the .50 caliber machine gun is of concern. The tank commander will get to fire this weapon system during gunnery as it is a requirement through all but Table IV, main gun only. The lack of this machine gun in the AGTS denies the tank commander the experience of simulated firing of this weapon system, or conducting simulated engagements that would incorporate this weapon with other weapon systems of the tank.

The replication of the loader and driver removes the variability of how long a loader takes to load a round and the driver's capability to maintain a steady speed or pull up into the fighting position to fire. This gives a false sense of the impact both members of the crew have on success or failure of the actual engagement. While minimizing variability to allow new tank commanders and gunners to focus on their specific tasks, the instructor/operator is not afforded the capability to introduce this variability as a crew becomes more proficient. This lack of variability in the AGTS results in new tank commanders and gunners having the variability due to the loader's and driver's abilities first introduced during the actual live-fire tables.

The AGTS uses electricity to run its systems. The actual tank is run by hydraulics. There is a difference in how the turret turns and the actual firing of the

weapon system. Although the difference is slight, it is noticeable and may impact a gunner's performance. Gunners with little experience may have difficulty transitioning as the tank responds differently; there is a minimal, but a noticeable difference in time between the input the gunner induces through his controls and the response by the tank. This is not replicated in the AGTS and can result in a new gunner having negative training transfer from the AGTS to the real tank.

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II. METHODS

The previous chapter outlined how the Army envisions conducting armor gunnery training. Studies have been conducted to try and determine how effective the simulator is at training crews prior to conducting live-fire gunnery on the real tank, with the last study being conducted over 20 years ago. The purpose of this thesis study is to determine if there is an association between AGTS and live-fire gunnery performance. This chapter describes the methodology of the thesis study, in particular, the demographic characteristics of the participants, the variables of interest, the selected AGTS and live-fire exercises, equipment, and procedures.

A. PARTICIPANTS

In order to assess training transfer from AGTS to live-fire among officers completing their first M1 Abrams tank course, 65 officers assigned to the Armor School Basic Officer Course were recruited and participated in the study. Participants had served in the active Army ($n = 40$), National Guard, ($n = 22$), or foreign armies ($n = 3$) with an average of 2.58 years of service ($sd = 0.337$). Participants ranged in age from 22 to 38 years (mean age was 24.78 years). Although 17 participants had a prior military occupational specialty indicating prior military service and training, none of these specialties were related to operating the M1 Abrams tank. Three officers had participated in live-fire gunnery prior to this study; however these officers had received training different from the current course of instruction and on different platforms than the M1 Abrams tank. Thus, all participants were in their initial training course on the M1 Abrams tank and had no prior experience with the M1 Abrams tank.

B. VARIABLES OF INTEREST

The variables of interest used to assess training transfer were overall crew score, time to identify the first target, time to kill the first and/or second target, and hit or miss of the target. All variables of interest were recorded on the Crew

Score sheet, DA Form 7657-R dated September 2009 by both the AGTS and during the live-fire gunnery exercises. The computer program in the AGTS automatically generates the score sheet based upon data automatically collected during the engagements conducted in the AGTS. Vehicle Crew Evaluators (VCE) collected the data for each engagement during the live-fire gunnery. Based on the crew score sheet, the continuous variables were the overall crew score, the time to identify the first target, and the time to engage the first target and the second target. The one categorical variable was whether a participant hit or missed the target. Below are descriptions of how each variable of interest was measured.

1. Overall Crew Score

The overall crew score is a compilation of the times recorded on identification of the target and the time(s) the target(s) were hit. If the crew makes an error such as an improper fire command or a safety violation, the crew may lose points. The crew's time in the defilade, while conducting a defensive engagement, is also factored into the overall score. The maximum score a crew can receive is 100 points. The minimum score to have a qualified run is 70 points, although the score is recorded to a minimum of zero points.

2. Time to Identify the First Target

The time is started when the target first appears. In the AGTS, the computer annotates the time when the target is first presented. In the live-fire gunnery, the time is started when the target is locked in the up position. The time for identification is recorded when one of the crew states "identified". This variable was measured in seconds.

3. Time to Kill the First and/or Second Target

The time is started when the target first appears. In the AGTS, the computer annotates the time when the target is first presented. In the live-fire gunnery, the time is started when the target is locked in the up position. The time

for engagement is recorded when the target is hit, or the target lowers based upon the exposure time of the target being met. This variable was measured in seconds.

4. Hit or Miss of a Target

The hit or miss of a target in the AGTS is displayed to the crew as a vehicle “burning”. The computer records the hit or miss, along with how many rounds were fired at that target and where the reticle was aiming at the time the rounds were fired. During the live-fire gunnery, the VCE records using a Forward Looking Infrared (FLIR) sight focused on the target to watch for the impact of the round. Each round has a tracer element in the back of the warhead that burns after it leaves the barrel allowing for FLIR and normal eyesight tracking. A hit was recorded based upon the round passing through the target and/or the target moving from the raised to lowered position. Hits were recorded as such, with misses being recorded as miss, lost, over, or short. A lost round is one where the VCE has determined the round did not hit the target, but could not identify exactly where the round passed in regards to the target. A round that goes over the target is one that the VCE sees as going over the target. A short round is one that hits short of the target.

C. EXERCISES

While participants executed numerous exercises in the AGTS, only the results of two exercises were captured for comparison to the live-fire results. These two AGTS exercises, 26081141 and 36011101, were similar to the modified live-fire gunnery Table V and VI. Since AGTS does not replicate the tank commander’s .50 caliber heavy machinegun, the modified live-fire gunnery engagements that used this weapon system were not used in the statistical analysis. A total of two engagements for Table V and Table VI were selected based upon types of targets engaged with particular weapon systems.

1. AGTS Exercises

Participants conducted various exercises in the AGTS during a week-long training program. These exercises were used by the instructors to teach the participants how to correctly operate the tank and engage targets. The training program culminated with the participants executing exercise 26081141 and 36011101.

a. AGTS Exercise 26081141

Exercise 26081141 was selected as it was the last exercise conducted prior to the GTLF exercise. This exercise was determined to be similar to a participant firing Table V which is the practice exercise prior to the participant live-fire qualification. This exercise was used to evaluate a participant's performance and whether they were able to progress to the GTLF exercise. A total of ten engagements were conducted in the exercise. Three particular engagements were selected that were similar to targets the participant would engage in their initial live-fire gunnery. Of these three engagements, two were chosen for statistical analysis with the live-fire Table V engagements. The first engagement was an individual tank which required the use of the main gun only. The second engagement was a PC and light vehicle which required the participant to engage using the main gun, and also the Coaxial Machinegun (COAX).

b. AGTS Exercise 36011101

Exercise 36011101 was the participants' GTLF exercise. The participant is required to pass this exercise to progress to the live-fire exercises. This requirement as a final exercise is similar to the participant completing the Table VI live-fire qualification.

This exercise was the participant's GTLF exercise, the final exercise before they executed live-fire gunnery. A total of ten engagements were conducted in the exercise. Two particular engagements were selected as they closely resembled the engagements that the participants conducted during their

final live-fire gunnery evaluation. The first engagement was an individual tank which required the use of the main gun only. The second engagement was two tanks which required the use of the main gun only.

The computer system that runs the simulation used by the AGTS also captures all of the variables used for this study.

2. Live

The participants conducted two live-fire gunnery iterations. The first iteration was the first time these participants fired the tank with live ammunition. The participants executed a total of five engagements during this first iteration. Four of the five engagements were selected as they were similar to engagements participants had seen in the AGTS exercise 26081141. The fifth was not used as it included an engagement that cannot be replicated in the AGTS, a target that the commander must engage using his .50 caliber machine gun. The four engagements were two PCs, one tank, one PC with troops, and one tank with troops. The two PCs and one tank engagements were main gun only while the PC with troops and tank with troops required the participant to use main gun and COAX. Of these four engagements, only two were used to conduct statistical analysis with the AGTS exercise 26081141. The first engagement was an individual tank which required the use of the main gun only. The second engagement was a PC and troops which required the participant to engage using the main gun, and also the COAX. Table 1 outlines the AGTS and live-fire exercises that were compared to each other.

The second iteration, the participant's final evaluation, the Table 6 modified live-fire, was a total of three engagements. One engagement was not used for the same reason that it required the commander to use his .50 caliber machinegun to engage the target. The other two engagements were selected for statistical analysis with AGTS exercise 36011101 due to their similarity with the engagements in AGTS exercise 36011101. The first engagement was an individual tank which required the use of the main gun only. The second

engagement was two tanks which required the use of the main gun only. Table 2 outlines the AGTS and live-fire exercises that were compared to each other.

Engagements Used for Study	AGTS Exercises 26081141 (Table 5)		Live Fire Gunnery Modified Table 5	
	Target Type 1	Target Type 2	Target Type 1	Target Type 2
Engagement One	Tank	N/A	Tank	N/A
Engagement Two	Personnel Carrier	Car	Personnel Carrier	Troops

Table 1. AGTS And Table 5 Engagements

Engagements Used for Study	AGTS Exercises 36011101 (Table 6)		Live Fire Gunnery Modified Table 6	
	Target Type 1	Target Type 2	Target Type 1	Target Type 2
Engagement One	Tank	N/A	Personnel Carrier	N/A
Engagement Two	Personnel Carrier	Personnel Carrier	Tank	Tank

Table 2. AGTS and Table 6 Engagements

D. SURVEY

Each participant was asked to complete an anonymous survey upon finishing their final live-fire gunnery exercise. This survey recorded the demographics of the participants, their previous gunnery training, how well they thought the AGTS trained them on each of several tasks, and their opinion as to what made an effective gunnery training program. It also allowed the participants to identify what other gunnery training they received and their perception of how that training benefited them in preparing them for live-fire gunnery. Ten specific tasks identified as being trained by the AGTS were included in the survey. The participants indicated whether they felt the AGTS actually accomplished this training compared to live-fire gunnery. The final question asked each participant's thoughts on what made an effective gunnery training program. See the appendix for the actual survey questions.

E. EQUIPMENT

The study compared participants on two pieces of equipment, The M1A2 SEPV2 main battle tank and the AGTS.

1. M1A2 SEPV2 Main Battle Tank

The M1A2 SEPV2 tank (see Figure 3) is the Army's front line tank. The tank is capable of firing on the move with targeting solutions determined by the embedded computer receiving data from the laser range finder and other on board systems. The tank is equipped with digital command and control systems that allow the tank commander to communicate using the Army's Force XXI Battle Command Brigade and Below (FBCB2). It also is equipped with standard FM radios.

The tank weaponry consists of a 120mm smooth bore main gun, one 7.62mm coaxial machinegun, one 7.62mm machinegun operated by the loader, and a .50 caliber heavy machinegun operated by the tank commander.

The gunner has a primary and an auxiliary sight that the tank commander can also see through. The tank commander also has a digital Commander's Independent Thermal Viewer (CITV) that he can use to spot and designate targets.

The M1A2 SEPV2 tanks used by the participants during the live-fire gunnery are maintained and issued by the Directorate of Training Sustainment.



Figure 3. M1A2 SEPV2 Main Battle Tank

2. AGTS

The AGTS is a simulator that replicates the gunner and tank commander stations for the M1A2 SEPV2 tank (see Figure 4). The layout is an exact replica of the interior of the tank with some minor differences. The simulator use computer generated graphics to portray what the gunner and tank commander see through the sights or periscopes, whether normal optical or thermal.

The coaxial machinegun is replicated in the simulator, but the gunner cannot manipulate the gun as is possible on the real tank. The breach of the 120mm main gun is replicated in its unfired position, but does not move up and down as the gunner moves his control handles. The gun also does not recoil like the real gun does when the gunner or tank commander fires the main gun. The driver and loader positions are replicated by the instructor/operator.

The AGTS is maintained and operated by personnel at the Clarke Simulation Center on Fort Benning, Georgia. The unit provides trained non-commissioned officers to be the instructor/operators (I/O) for the training of the participants.



Figure 4. Advanced Gunner Training System (from au-corp.com, 2014)

F. PROCEDURES

The overall concept of the study was to not interfere with the already established training program for armor crew gunnery. The participants executed AGTS followed by the live-fire. The survey was provided to the participants at the conclusion of their live-fire gunnery. IRB approval was attained prior to data collection.

The AGTS data was collected by the individual crew I/O. This data was printed for each individual participant with the tank commander identified as the primary trained individual. The two exercise series collected were numbered 26081141 and 36011101. These two exercise series were equitable to the two live-fire exercises conducted.

As per the established training program, The I/O had the participants' progress through various exercises. Based upon the participants' progress, and the remaining training time, the I/O determined if the participants' would progress through all of the exercises, or culminate prior to completing the 36011101, GTLF. The I/O made this determination based upon his experience on whether the participant was prepared to execute the live-fire gunnery safely.

Upon completion of the AGTS training, the participants moved to the live-fire portion of the training program. Each participant fired five total engagements for the first exercise. This was the first time any of the participants had fired live from a tank. The engagements were observed and recorded by the VCEs on the crew score sheet. The results of the exercise were briefed to each individual participant in their AAR. A copy of all score cards was made and provided to the study team.

The final live gunnery exercise consisted of three engagements. This exercise was also considered the participants' final evaluation in the gunnery training program for the unit. The engagements were observed and recorded by the VCEs on the crew score sheet. The results of the exercise were briefed to

each individual participant in their AAR. A copy of all score cards was made and provided to the study team.

After the participant had completed their final live-fire exercise, they filled out their survey. This survey was provided in paper copy to each participant who filled it out with a pen or pencil. Once the participant completed the survey, they placed them in a separate file folder.

III. RESULTS

This chapter discusses the statistical results of the study. First, the preliminary results provide an overview and side by side comparison of participants' performance in the AGTS and live fire exercises. Next, the main research question of whether there is a correlation between the results of the participant's performance in the AGTS and their performance during live fire gunnery is addressed. The research question is addressed separately for Table 5 and Table 6.

Finally, an opportunity to conduct a comparison between participants who had completed the AGTS GTLF exercise 36011101 and those that had not resulted when the training unit allowed instructors to certify a participant was safe to execute live fire gunnery whether or not they had completed the AGTS GTLF. To complete all of the AGTS exercises, the participant had to have completed the Gate to Live Fire, exercise 36011101. A total of 34 participants completed the GTLF and 30 did not. Therefore, exploratory analyses were conducted to determine whether participants performed better if they had completed all of the AGTS exercises compared to those that had not completed all of the AGTS exercises. For all of the statistical analyses reported in this chapter, a two-tailed $\alpha=0.05$ was used.

A. PRELIMINARY RESULTS

Prior to testing the main hypothesis of how people performed, descriptive statistics on participants' performance in the AGTS and live fire exercises were calculated. Paired t-tests next were completed to determine if participants performed significantly better or worse in the live fire exercise compared to the AGTS exercise.

Table 3 shows the summary of results for AGTS exercise 26081141 and gunnery Table 5. There was a trend for participants to do better in the AGTS than in the live fire gunnery for the overall score ($t(11) = 2.087, p=.061$). There were

no significant differences for (kill times of the first target: $t(11) = -0.221$, $p=0.829$; or kill times of the second target $t(4) = -0.829$, $p=0.454$). Results from a two proportion z test also indicated no significant difference in the hit rate percentage of 75% for AGTS and 81.30% for the modified live fire gunnery Table 5.

Table 5	AGTS Exercise 26081141	Live Fire Gunnery Modified
Overall Score	47.667(44.75), 0-100 (n=12)	23.083(32.469), 0-89 (n=12)
ID Time	N/A	N/A
Kill Time Target One	33.942(14.665), 3.9-58 (n=12)	35.667(18.242), 14-67 (n=12)
Kill Time Target Two	72.06(14.472), 52.5-87.6 (n=5)	90.8(55.899), 42-180 (n=5)
Hit Rate Percentage	75%	81.30%

Table 3. Summaries of Results (Table 5): Mean (SD), range (sample size)

Table 4 shows the summary of results for AGTS exercise 36011101 and gunnery Table 6. Results from paired t-tests showed that participants did significantly better in the AGTS than in the live fire gunnery for the overall score ($t(66) = 3.975$, $p=.0002$ and identification time ($t(33)=-3.899$, $p=.0004$), and hit rate percentage of 97% for AGTS and 66.70% for the modified live fire gunnery Table 6. However, participants did significantly better in the live fire for the kill time of the first target ($t(64) = 2.157$, $p=0.035$) and the kill time of the second target ($t(31) = 5.579$, $p<0.0001$).

Table 6	AGTS Exercise 36011101	Live Fire Gunnery Modified
Overall Score	73.522(28.784), 0-100 (n=67)	49.03(36.603), 0-100 (n=67)
ID Time	9.147(4.027), 4.2-18.3 (n=34)	21.529(17.173), 5-79 (n=34)
Kill Time Target One	31.694(14.603), 11.6-65.1 (n=65)	24.908(17.349), 6-91 (n=65)
Kill Time Target Two	61.619(19.682), 31.5-100.5 (n=32)	36.313(13.025), 17-79 (n=32)
Hit Rate Percentage	97%	66.70%

Table 4. Summaries of Results (Table 6): Mean (SD), range (sample size)

B. MAIN HYPOTHESIS

Is there a correlation between the crew score during the Gate to Live Fire (GTLF) exercise utilizing the Advanced Gunnery Training System and Table 5 and 6 live fire gunnery?

The main hypothesis was tested using Pearson correlations on all variables of interest: overall crew score, time to identify the first target, time to kill the first target, time to kill the second target, and the hit or miss of the target. Below, results from gunnery Table 5 are shown, followed by results from gunnery Table 6.

1. Gunnery Table 5 Results

There was no significant correlation between the AGTS and modified live fire performance of participants for overall crew scores ($r=0.478$, $p=0.12$), first target kill time ($r=-0.347$, $p=0.269$), second target kill time ($r=0.483$, $p=0.41$). Results were not captured time to identify the first target in the AGTS exercise 26081141 and gunnery Table 5. The engagements in gunnery Table 5 that were the most similar to the AGTS were offensive engagements. Offensive engagements do not have a recorded identification time in the live fire gunnery. Regarding the percentage of hits, the sample size was not large enough to determine what the conditional probability was for the gunnery Table 5 hit or miss of targets. There is a trend though, that if a participant hit in the AGTS, they will hit in the modified live fire gunnery (see Table 5).

	Live		
AGTS	Hit	Miss	Totals
Hit	10	2	12
Miss	3	1	4
Totals	13	3	16

Table 5. Number of Hits and Misses for AGTS Exercise 26081141 and Gunnery Table 5

2. Gunnery Table 6 Results

There was no significant correlation between the performance in overall crew score in the AGTS and in the modified live fire ($r=-0.178$, $p=0.15$), time to identify the first target ($r=-0.23$, $p=0.19$), or for the second target kill time ($r=-0.198$, $p=0.277$). However, there was a significant correlation between first target kill time in AGTS and live fire ($r=-0.255$, $p=0.04$). Finally, conditional probability calculations demonstrate that given that a participant had a hit in the AGTS, there is 66.7% likelihood that they would also have a hit in the modified live fire gunnery. (Probability of an AGTS hit was $99/102=0.971$. The probability of an AGTS hit and a live hit was $66/99=0.647$). Table 6 shows the raw number of hits and misses between AGTS and live-fire gunnery.

		Live		
		Hit	Miss	Totals
AGTS	Hit	66	33	99
	Miss	2	1	3
	Totals	68	34	102

Table 6. Number of Hits and Misses for AGTS Exercise 36011101 and Gunnery Table 6

C. EXPLORATORY ANALYSIS

Exploratory analyses were conducted to determine if there was a statistical significant difference in live fire performance between those who had completed all of the AGTS exercises and those that had not. To complete all of the AGTS exercises, the participant had to have completed the Gate to Live Fire, exercise 36011101. *F* tests for equal variances indicated that two sample *t*-tests assuming equal variances could be used for all the exploratory analyses.

1. Overall Crew Score

There was a trend for participants who completed AGTS to score higher than those who did not complete the AGTS ($t(124)=1.902$, $p=0.059$) (see Table 7).

Overall Score	Participant Who Completed AGTS	Participant Who Did Not Complete AGTS
Mean	49.03	36.933
Standard Deviation	36.603	34.835
Observations	67	60
Hypothesized Mean Difference	0	
df	125	
t Stat	1.902	
P(T<=t) two-tail	0.059	
t Critical two-tail	1.979	

Table 7. Overall Score t-Test: Two-Sample Assuming Equal Variances

2. Time to Identify the First Target

There was a trend for participants who completed the AGTS to have faster identification times than those who had not completed AGTS ($t(62)=-1.986$, $p=0.051$) (see Table 8).

Identification Time	Participant Who Completed AGTS	Participant Who Did Not Complete AGTS
Mean	21.529	34.633
Standard Deviation	17.173	33.885
Observations	34	30
Hypothesized Mean Difference	0	
df	62	
t Stat	-1.986	
P(T<=t) two-tail	0.0515	
t Critical two-tail	1.999	

Table 8. Identification Time t-Test: Two-Sample Assuming Equal Variances

3. Time to Kill the First Target

Those who completed AGTS training had a significantly lower target one kill time than those who had not completed AGTS ($t(124)=-2.174$, $p=0.032$) (see Table 9).

Kill Time Target 1	Participant Who Completed AGTS	Participant Who Did Not Complete AGTS
Mean	24.522	34.237
Standard Deviation	17.230	31.651
Observations	67	59
Hypothesized Mean Difference	0	
df	124	
t Stat	-2.174	
P(T<=t) two-tail	0.0316	
t Critical two-tail	1.979	

Table 9. Time to Kill the First Target t-Test: Two-Sample Assuming Equal Variances

4. Time to Kill the Second Target

Those who completed AGTS training had a significantly lower target two killing time than those who had not completed AGTS ($t(60)=-2.236$, $p=0.029$) (see Table 10).

Kill Time Target 2	Participant Who Completed AGTS	Participant Who Did Not Complete AGTS
Mean	35.879	42.621
Standard Deviation	13.059	10.290
Observations	33	29
Hypothesized Mean Difference	0	
df	60	
t Stat	-2.236	
P(T<=t) two-tail	0.029	
t Critical two-tail	2.001	

Table 10. Time to Kill the Second Target t-Test: Two-Sample Assuming Equal Variances

5. Hit or Miss of a Target

There is no statistical significance in hits or misses on whether a participant completed the training in AGTS or not ($z=-0.76$, $p=0.447$). Those who did not complete the AGTS had a slightly higher proportion of hits than those that completed the training. The proportion of hits with AGTS is 68.3% while the proportion of hits without AGTS is 73.3%. Table 11 outlines the percentage of misses that were characterized as short, over, or lost, or simply as a miss.

Misses	Participant Who Completed AGTS	Participant Who Did Not Complete AGTS
Short	(14/32) 44%	(10/24) 42%
Over	(17/32) 53%	(9/24) 38%
Lost	(1/32) 3%	(4/24) 17%
Miss	(0/32) 0%	(1/24) 4%

Table 11. Percentage of Misses

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IV. RECOMMENDATIONS AND CONCLUSION

This chapter discusses the recommendations based upon the results from the main hypothesis and the exploratory question. First, the main hypothesis and the resulting lack of correlation for the variables of interest are discussed. The exploratory question's results and use as a metric for demonstrating training effectiveness is highlighted. Finally recommendations for future studies and work are presented.

A. DISCUSSION

The analysis of the participants' performance during their AGTS exercises and modified live-fire gunnery showed no significant correlation. This is a similar result to the studies conducted 20 years ago found. We also compared the results of the participants who had completed the AGTS training program and those that had not. The participants who completed the AGTS training had a significantly better performance than those who did not complete the training. The result of this comparison is important as it may provide a better indicator of training effectiveness than correlation.

1. Main Hypothesis

As stated in Chapter III, the H_0 was retained. There was no significant correlation found between the participants' performance in the AGTS and their performance in the modified live fire gunnery. The lack of correlation between the performance in a simulator and performance in a live setting may appear to suggest that training transfer is not occurring, but we believe correlation is the wrong metric to assess training transfer.

a. *AGTS Exercises and Modified Live-Fire Gunnery*

While there was no significant correlation found, the sample sizes for conducting the analysis were small. A sample size of only 12 could be used for the overall crew score and time to kill the first target. A sample size of only five

could be used for the time to kill the second target. The small sample size was due to a lack of recorded AGTS exercise 26081141 that corresponded with recorded gunnery Table 5 performance.

Participants had conducted nine exercises in the AGTS prior to executing exercise 26081141. These exercises were used as foundational building blocks to introduce the participants to operating the tank, and firing the tank as part of a crew. The participants were able to learn the switches, knobs, and buttons necessary to conduct an engagement. Participants were also introduced to target identification and acquisition.

The participants' first live round fired from a tank was their first engagement on the Table 5. While they had fired numerous "rounds" in the simulator, the lack of breach recoil and realistic sound in the simulator does not adequately prepare someone for the experience of firing a live round from the main gun of the tank. Additionally, the targets the participant saw in the simulator are completely different than what the participant saw on the live fire range. In the simulator, the participant saw full silhouettes of enemy vehicles. On the live fire range, the targets are plywood painted dark green that are either rectangular for a PC, rectangular with a smaller rectangle on top to represent the front of a tank, or troop silhouettes.

Participants did have better time to kill target one and two times on the gunnery Table 6 than their AGTS exercise 36011101. This may be a result of the participant having some familiarity with the range. If this familiarity with the range and the targets is the factor for improved times, then the question must be asked of how to better transition an individual from the simulator to the live fire.

The better performance in AGTS than in the live fire exercises may be a result of the crews progressing through numerous exercises/engagements prior to executing the two exercises used in this study. Since the graphics are not representative of what a crew sees as a target on the range, or in real-world

operations, the crew has to relearn exactly what they are looking at, which affects all variables of interest.

2. Exploratory Question

This study was fortunate to be able to compare participants that had completed the AGTS exercise 36011101 with those that had not. The training unit has a policy that allows individuals to progress to the live fire gunnery without completing the GTLF as long as the instructor feels the individual is safe enough to execute the live fire. This resulted in having 34 participants that had completed the GTLF and 30 that had not. While the overall crew score and identification time only showed a trend of those that had completed the GTLF as having a better performance, the kill times of the first and second target were significantly better.

The better performance of the participants that completed GTLF suggests that training transfer may be occurring. While training was constrained by time, the ultimate goal was for each participant to complete all exercises including the GTLF. This suggests that the satisfactory completion of all exercises is more important than just having individuals spending time in the simulator. Remedial training must be used for those individuals to ensure progression through the training exercises.

B. RECOMMENDATIONS AND CONCLUSION

This study demonstrates that simulations can have a positive impact in the training of individuals for tank gunnery. The critical component to ensure the simulator is being used to maximize the training of crews is to identify exactly what tasks the simulator can train. If these tasks are identified, the simulator does not become a “check the block” requirement, but a critical enabler in the training methodology. Tasks that are not trained in the simulator can also be addressed in the training plan that commanders establish to prepare crews for live fire gunnery. This identification and understanding of capabilities not only

allows commanders to maximize their training, but to tailor their training to crew specific training needs.

The better performance of those who completed the AGTS compared to those who did not is a case for having the trailer equipped mobile AGTS present on the range during the live fire gunnery. As crews progress through the live fire tables, and based upon their AARs, crews should be able to use the simulator to train deficient tasks. This method would use the simulator as an enabler to training and not just a “check the block” event.

Metrics must be established that allow commanders and trainers to monitor a crews progress through their training. A simulation based training methodology that results in individuals attaining a higher level of proficiency than would be attained by just live training is the ultimate goal.

1. Future Study

This study was a relative small snapshot of armor training and the use of simulators to train armor crews. Additionally, for some variables of interest, the sample sizes were small. Future studies that have ample sample sizes for each variable of interest could investigate:

- Conducting an observational study of a deployable active duty unit for the same variables of interest;
- What metrics explain how training transfer is occurring;
- Evaluating the close combat tactical trainer capabilities versus the AGTS;
- Task evaluation of a unit training plan based upon those tasks that are trained live versus through simulations;
- The effect of realistic graphics on training.

The use of simulators to train tasks will become more prevalent in the military. Fiscal constraints will limit the amount of live training that can be conducted. Decreasing deployments mean more units need to conduct home station training which decreases the amount of time units have to train on live ranges. The use of simulations and simulators has the potential to enable units to

maximize live training by training tasks in simulation to a level of proficiency that previously could only be trained using live fire training.

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APPENDIX A. SURVEY QUESTIONS

What United States Military Service are you?

US Army US Marine Corps

Years of Military Service (to include active and reserve)? _____

Prior Military Service (yes or no)? _____

If yes, highest rank attained _____

If yes, Military Occupational Specialty (MOS) _____

If yes, how many years _____

Current Age? _____

Have you ever conducted tank gunnery before? _____

If yes, please describe when, where, position on crew, and how many gunneries conducted.

Please describe what other training besides the AGTS (simulator) that you conducted before executing your live fire gunnery.

Please explain the benefits and/or drawbacks of the other training you described above.

How well did the exercises in the AGTS prepare you for live fire gunnery.

- ☐ Completely prepared me
- ☐ Somewhat prepared me
- ☐ Not sure
- ☐ Somewhat prepared me
- ☐ Did not prepare me at all

Please explain the benefits and/or drawbacks of training in the AGTS simulator.

What tasks did you feel the AGTS best replicated compared to live fire gunnery. Mark all that apply.

- | | |
|---|---|
| <input type="radio"/> Use of the fire control system (GCDP) | <input type="radio"/> Issuing fire commands |
| <input type="radio"/> Use of the fire control system (CITV) | <input type="radio"/> Use of fire control system (CID) |
| <input type="radio"/> Responding to fire commands | <input type="radio"/> Proper engagement techniques |
| <input type="radio"/> Proper engagement procedures | <input type="radio"/> Target acquisition |
| <input type="radio"/> Target identification | <input type="radio"/> Laying the main gun for direction |

What tasks did you feel the AGTS did not replicate compared to live fire gunnery. Mark all that apply.

- | | |
|---|---|
| <input type="radio"/> Use of the fire control system (GCDP) | <input type="radio"/> Issuing fire commands |
| <input type="radio"/> Use of the fire control system (CITV) | <input type="radio"/> Use of fire control system (CID) |
| <input type="radio"/> Responding to fire commands | <input type="radio"/> Proper engagement techniques |
| <input type="radio"/> Proper engagement procedures | <input type="radio"/> Target acquisition |
| <input type="radio"/> Target identification | <input type="radio"/> Laying the main gun for direction |

What do you think an effective armor gunnery training program should contain? Be specific. _____

Any other comments you would like to make.

APPENDIX B. IRB APPROVAL LETTER



Naval Postgraduate School Human Research Protection Program

From: President, Naval Postgraduate School (NPS)
To: Dr. Quinn Kennedy, Operation Research Department (OR)
Mr. Jeff Appleget, Operation Research Department (OR)
Mr. Perry McDowell, Modeling, Virtual Environments and
Simulation Institute (MOVES)
Mr. Jesse Huston, Modeling, Virtual Environments and
Simulation Institute (MOVES)
MAJ Dennis Wagner, USA
Via: Chairman, Institutional Review Board (IRB)
Subj: TRAINING EFFECTIVENESS STUDY OF SIMULATOR USAGE AND ITS
IMPACT ON LIVE FIRE ARMOR GUNNERY

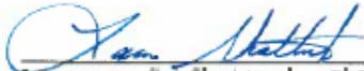
Encl: (1) Approved IRB Initial Review Protocol

1. The NPS IRB is pleased to inform you that the NPS President has approved your initial review protocol (NPS IRB# NPS.2014.0031-IR-EP7-A). The approved IRB Protocol is found in enclosure (1). Completion of the CITI Research Ethics Training has been confirmed.
2. This approval expires on 30 June 2014. If additional time is required to complete the research, a continuing review report must be approved by the IRB and NPS President prior to the expiration of approval. At expiration all research (subject recruitment, data collection, analysis of data containing PII) must cease.
3. You are required to obtain consent according to the procedure provided in the approved protocol.
4. You are required to report to the IRB any unanticipated problems or serious adverse events to the NPS IRB within 24 hours of the occurrence.
5. Any proposed changes in IRB approved research must be reviewed and approved by the NPS IRB and NPS President prior to implementation except where necessary to eliminate apparent immediate hazards to research participants and subjects.
6. As the Principal Investigator (PI) it is your responsibility to ensure that the research and the actions of all project

Subj: TRAINING EFFECTIVENESS STUDY OF SIMULATOR USAGE AND ITS
IMPACT ON LIVE FIRE ARMOR GUNNERY

personnel involved in conducting this study will conform with
the IRB approved protocol and IRB requirements/policies.

7. At completion of the research, no later than expiration of
approval, the PI will close the protocol by submitting an End of
Experiment Report.



Lawrence G. Shattuck, PhD
Chair
Institutional Review Board



Ronald A. Route
Vice Admiral, U.S. Navy (Ret.)
President, Naval Postgraduate School

Date: FEB 26 2014

APPENDIX C. CONSENT FORM

Naval Postgraduate School Consent to Participate in Research

Introduction. You are invited to participate in a research study entitled Training Effectiveness Study of Simulator Usage and its Impact on Live Fire Armor Gunnery. The purpose of the research is to determine if there is a correlation between the crew score during the Gate to Live Fire (GTLF) exercise utilizing the Advanced Gunnery Training System (AGTS) and Table VI live fire gunnery qualification.

Procedures. This study will collect data on the tank commander and gunners as a team and their results in the AGTS and during the Table VI live fire gunnery qualification. A survey will be given to all participants at the end of their live fire gunnery portion of the study to gain a subjective understanding of the individual's experience.

- A brief will be given of an overview of the study and participant involvement. Following the brief, all volunteers will fill out a standard consent form, providing either consent to all of the study. After the consent form is filled out, participants will be logged into the subject log and receive your subject ID number. Data from the experiment will only be referenced using the subject ID number. All data in the final report will be reported in aggregate.
- Participants will execute the AGTS portion of the study based upon the current program of instruction for the Armor Officer Basic Leader Course. The duration of this portion of the study is based upon the unit's current training schedule and will not be modified for the purposes of this study. The Advanced Gunnery Training System data collected will be the results of the crew the computer captures and prints as part of the feedback capability to include the computer generated crew gunnery score sheet.
- Participants will execute the live fire gunnery portions of the study based upon the current program of instruction for the Armor Officer Basic Leader Course. The duration of this portion of the study is based upon the unit's current training schedule and will not be modified for the purposes of this study. During the Table VI live fire gunnery qualification, the crew's scores will be collected once the firing scenarios are completed and the Tank Crew Evaluator and Master Gunner verify the crew gunnery score sheet.
- A survey will be given to all participants at the conclusion of the live fire gunnery portion of the study. This survey should take approximately 20 minutes and will provide a better understanding to the data collected. If additional clarification is required, you may be contacted by the researcher by email.
- The population that is asked to participate in this study is the current Armor Officer Basic Leader Course in training. Actual participation is voluntary.
- Data will be reported in aggregate; though specific results may be referenced in academic publications with no reference to you, unless consent is provided by the subject. Your individual results will not be released to any entity or agency.
- There will be no audio or video recording used in this study.
- There is no cost to participate in this research study.

Location. The interview/survey/experiment will take place at Fort Benning Georgia at varying training venues based upon the training scheduled published by chain of command.

Voluntary Nature of the Study. Your participation in this study is strictly voluntary. If you choose to participate you can change your mind at any time and withdraw from the study. You will not be penalized in any way or lose any benefits to which you would otherwise be entitled if you choose not to participate in this study or to withdraw. The alternative to participating in the research is to not participate in the research.

Potential Risks and Discomforts. It is anticipated that there will be no to minimal risk or discomfort that will be present during this study. This study is observing current training that has been approved by the Maneuver Center of Excellence. There will be no change to the current training, and as such, participants are executing tasks they are required to in the execution of their training regardless of participation in the study. The only change to the training will be the addition of the survey at the end. This survey will be strictly anonymous, and only aggregate data may be provided to the unit.

Anticipated Benefits. Anticipated benefits from this study are in relation to better determining where, who, and how much simulator training is required for equal or better execution in the live gunnery environment. Through collected data of both simulator training and live fire gunnery and the statistical analysis of this data, it will be determined if units can use the data provided through training venues to target critical tasks and specific crews to improve the overall qualification score.

Compensation for Participation. No tangible compensation will be given.

Confidentiality & Privacy Act. Any information that is obtained during this study will be kept confidential to the full extent permitted by law. All efforts, within reason, will be made to keep your personal information in your research record confidential but total confidentiality cannot be guaranteed. Each subject's name and contact information will be captured on a spreadsheet and a study identification number will be assigned. This document will be stored separately from all data. All data in the study will be recorded electronically, using the study identification number. Once the study is complete, the hard copy of the subject's contact information and study identification number will be destroyed. No information from this study will be reported to the subject's chain of command. All other data will be stored electronically on access controlled computers at the Naval Postgraduate School. Any information that is obtained during this study will be kept confidential to the full extent permitted by law. If you consent to be identified by name in this study, any reference to or quote by you will be published in the final research finding only after your review and approval. If you do not agree, then you will be identified broadly by discipline and/or rank, (for example, "fire chief").

☐ I consent to be identified by name in this research study.

☐ I do not consent to be identified by name in this research study.

Points of Contact. If you have any questions or comments about the research, or you experience an injury or have questions about any discomforts that you experience while taking part in this study please contact the Principal Investigator, Dr. Quinn Kennedy 656-

2618, mqkenned@nps.edu. Questions about your rights as a research subject or any other concerns may be addressed to the Navy Postgraduate School IRB Chair, Dr. Larry Shattuck, 831-656-2473, lgshattu@nps.edu.

Statement of Consent. I have read the information provided above. I have been given the opportunity to ask questions and all the questions have been answered to my satisfaction. I have been provided a copy of this form for my records and I agree to participate in this study. I understand that by agreeing to participate in this research and signing this form, I do not waive any of my legal rights.

Participant's Signature

Date

Researcher's Signature

Date

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